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SPATIAL RELATIONSHIPS AMONG QUAIL COVEYS

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SPATIAL RELATIONSHIPS AMONG QUAIL COVEYS[1]

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Abstract: The nearest-neighbor method of measuring spatial relationships (Clark and Evans 1954) was used to evaluate the patterns of distribution among quail (*Colinus virginianus*) coveys on a 275-acre portion of a public hunting area in Illinois for the years 1963–1967. Covey distribution did not depart significantly from random, except that in the spring, when population levels were lowest (prebreeding period, March) there appeared to be a consistent tendency toward a uniform dispersion of coveys. Although there was a significant positive correlation between population size and mean covey size, a change in the number of coveys was the primary reflection of changes in quail abundance. Knowledge of the patterns of distribution is considered essential to an evaluation of management effectiveness.

This paper discusses the relationship between density and dispersion of quail coveys and habitat management on a 275-acre portion of a pubic hunting area intensively managed for bobwhites and cottontail rabbits (*Sylvilagus floridanus*).

The problem of evaluating quail habitat is difficult. Traditionally, the game manager has used one criterion of management effectiveness—abundance. Dispersion is a second important population characteristic influenced by habitat.

Members of a population, in this case coveys, could be dispersed over their range in three general patterns: (1) random; (2) uniform (more regular than random); (3) aggregated or clumped, or some combination of these (Odum 1959). Social behavior, population density, and habitat would determine the actual pattern of dispersion.

Random distributions are believed to be rare in nature and are expected only where habitat and social attraction or repulsion have no effect on dispersion patterns or where habitat components are randomly distributed. Uniform distributions occur where severe competition promotes even spacing in uniform habitats. Aggregation is undoubtedly the commonest situation and may result from either nonuniform habitat or a social tendency to aggregate.

In management of public hunting areas for quail, the objectives are to achieve uniformly good habitat, and to maintain adequate distances between hunting parties for hunter safety. Coveys tend to be clumped on existing areas of suitable habitat, with management striving to achieve

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a more regular distribution of coveys by creating uniformly favorable range.

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METHODS

Study Area

This study was conducted on a 275-acre portion of the Sam Dale Lake Conservation Area in Wayne County, Illinois. The area is a state-owned, multiple-use recreational area, with upland game hunting a major recreational use. Prior to state acquisition in 1960 and 1961, the area was agricultural land in row crops, small grains, and pastures. There are at present approximately 125 acres of open land, 60 acres in mixed oak–hickory hardwoods, 40 acres in blocks of pines planted in 1962, and the remaining acreages in roads, picnic areas, and an air strip.

Management for the area was designed and implemented by the Division of Game, Illinois Department of Conservation. The open fields were seeded to redtop (*Agrostis alba*) and timothy (*Phleum pratense*) in the fall of 1961. These fields were divided into smaller units in 1962, with approximately 6 miles of multiflora rose (*Rosa multiflora*), in double rows, used as border strips. Since 1962, management emphasis has been placed on establishment of annual food patches such as corn (*Zea mays*), sorgo (*Sorghum vulgare*), buckwheat (*Fagopyrum esculentum*), and several millets. In 1965, for example, 22 food patches comprising 21 acres were planted in the open fields.

Quail Census

Bird dogs were used to locate quail coveys on the study area during late October or early November (prehunt), late December or early January (posthunt), and mid-March (prebreeding), from the fall of 1963 through the spring of 1967. Each of the 12 censuses was made in a consistent pattern during weather conditions favorable for locating quail. To reduce the possibility of recounting coveys, censuses were made during 1 day; the direction of flight from the flush site, and the number of quail in each covey were noted.

Measuring Dispersion

The technique of Clark and Evans (1954) was used to provide a measure of the patterns of dispersion of quail coveys. This technique utilizes the distance to nearest neighbors (quail coveys, in this instance) as a basis for calculating dispersions within populations. The distance between each covey and its nearest neighboring covey was measured to the nearest 0.01 mile and covey density was calculated as coveys per square mile. The Clark–Evans model requires that linear distances and calculations of density be in the same units—in our case, miles. R values were calculated using the formula derived by Clark and Evans (1954: 447) where:

"N the number of measurements of distance taken in the observed population or sample . . .

r the distance in any specified units from a given individual to its nearest neighbor.

ρ the density of the observed distribution expressed as the number of individuals per unit of area . . .

$\bar{r}_A = \dfrac{\Sigma r}{N}$ the mean of the series of distances to nearest neighbor.

$\bar{r}_E = \dfrac{1}{2\sqrt{\rho}}$ the mean distance to nearest neighbor expected in an infinitely large random distribution of density rho.

$R = \dfrac{\bar{r}_A}{\bar{r}_E}$ the measure of the degree to which the observed distribution departs from random expectation with respect to the distance to nearest neighbor."

"In a random distribution, R = 1. Under conditions of maximum aggregation, R = 0. . . . Under conditions of maximum spacing, individuals will be distributed in an even, hexagonal pattern, and every individual (except those at the periphery of the population) will be equidistant from six other individuals. In such a distribution, the mean distance to nearest neighbor will be maximized and will have the value $\dfrac{1.0746}{\sqrt{\rho}}$. . . . When this is the case, R = 2.1491." [Clark and Evans (1954: 447).]

Table 1. Summary of quail abundance on a 275-acre portion of the Sam Dale Lake Conservation Area, Wayne County, Illinois.

	Year 1963–64	1964–65	1965–66	1966–67	Totals	Percent Change from (1)	Percent Change from (2)
(1) Prehunt census							
No. coveys	9	8	5	7	29		
No. quail	160	130	79	109	484		
Avg. quail per covey	17.8	17.0	15.8	15.6	16.7		
(2) Posthunt census							
No. coveys	3	7	3	4	17	−41	
No. quail	36	77	28	43	184	−62	
Avg. quail per covey	12.0	11.0	7.3	10.8	10.8	−35	
(3) *Prebreeding census*							
No. coveys	4	3	2	5	14	−52	−18
No. quail	24	20	25	46	124	−74	−33
Avg. quail per covey	6.0	7.7	12.5	9.2	8.9	−47	−18

A test of significance for small samples is based on the probability of difference between $\bar{r}_A$ and $\bar{r}_E$, would follow the Chi-square distribution. Using the notation of Clark and Evans (1954:447), the test is:

$$\chi_2^2 = 2\pi\rho k^{-1}\sum_{i=1}^{N} r_i^2;\ d\,f = 2(N-1)$$

Multiple correlation and covariance analyses were used to evaluate possible relationships among covey densities, average size of coveys, total numbers of quail on the study area, average distance between nearest neighboring coveys, and R, the index of covey dispersion. Data for each census for each year (total, 12) were treated as independent observations.

RESULTS

Population Levels

Quail abundance tended toward declining fall populations during the first 3 years and an increase the 4th year (Table 1). The expected decline in quail numbers from fall-to-winter-to-spring was also evident in these data. The 1964 and 1967, prebreed-

Table 2. Spatial relationships among quail coveys during prehunt, posthunt, and prebreeding censuses on the Sam Dale Lake Conservation Area, Wayne County, Illinois.

Census	1963-64	1964-65	1965-66	1966-67
Prehunt coveys	9	8	5	7
ρ = Density (coveys/1 square mile)	18.60	16.28	9.30	13.95
$\bar{r}_A$ = Mean observed intercovey distances (miles)	0.09	0.13	0.19	0.17
$\bar{r}_E$ = Mean expected intercovey distances (miles)	0.12	0.12	0.16	0.13
R = Dispersion value	0.77	1.07	0.88	1.28
χ_2^2 = Test of significance	12.40	16.81	6.49	11.73
Posthunt coveys	5	7	3	4
ρ = Density (coveys/1 square mile)	4.65	13.95	4.65	0.98
$\bar{r}_A$ = Mean observed intercovey distances (miles)	0.35	0.11	0.19	0.32
$\bar{r}_E$ = Mean expected intercovey distances (miles)	0.23	0.13	0.23	0.19
R = Dispersion value	1.51	0.81	0.82	1.69
χ_2^2 = Test of significance	11.58	11.10	3.44	17.85*
Prebreeding coveys	4	3	2	5
ρ = Density (coveys/1 square mile)	6.98	4.65	2.33	9.30
$\bar{r}_A$ = Mean observed intercovey distances (miles)	0.26	0.34	0.30	0.21
$\bar{r}_E$ = Mean expected intercovey distances (miles)	0.19	0.23	0.33	0.16
R = Dispersion value	1.40	1.42	1.09	1.27
χ_2^2 = Test of significance	12.64	11.30	3.79	17.62

* $P < 0.05$.

ing censuses suggested that one covey may have immigrated onto the study area after the preceding posthunt censuses.

Changes in both covey size and number were closely correlated with the total number of quail, while fewer and smaller average covey sizes were associated with reductions in population size.

The average size of coveys during the prehunt period ranged from 15.6–17.8 quail, with a mean of 16.7 birds. While the larger covey sizes again tended to be associated with higher population levels, the primary reflection of fall-to-fall change in the abundance of quail was noted in the number of coveys found on the study area. In general, when populations were high, coveys were both larger and more numerous than when populations were low.

Dispersion

Measures of dispersion (R) of quail coveys ranged *from 0.77 during the 1963–64* prehunt census to 1.69 during the 1966–67 posthunt census (Table 2). Of the 12 censuses, only the latter value for 1966-67 indicated a significant departure from randomness toward uniformity ($P < 0.05$). Because these tests were based on few coveys, there is a high probability of Type II error.

All four of the R-values obtained during the prebreeding censuses were greater than 1. The probability of this occurring by chance is 0.0625; thus, a tendency towards a uniform distribution of quail coveys just prior to breeding was indicated.

As covey density decreased, there was an increase in $\bar{r}_A$, the average distance between coveys, that is, the fewer the coveys the farther apart they were. The relationship between dispersion, R, and covey density indicated that greater uniformity was associated with lower density situations; however, the test statistic for this relationship was not significant ($P < 0.05$). Because *the lower densities were observed on the* prebreeding censuses, the tendency toward uniformity may be attributed to density or habitat conditions, *but some phenomena of* behavior associated with the impending breeding season may also be responsible. Wynne-Edwards (1962:15–16) noted that "territorial convention in birds tends to be most active and vigorous . . . just before mating and egg-laying take place;" and could, therefore, explain the tendency toward uniformity.

DISCUSSION

Observations *of the behavior and function* of quail coveys reported in the literature can be summarized as follows: (1) a covey is an aggregation of individuals regularly inhabiting an area; (2) territories of individual coveys may overlap; (3) survivors from one covey may combine with individuals in other coveys (Stoddard 1931: 169, Murphy and Baskett 1952:504). Bartholomew (1967:20, 24) observed that winter covey groups maintained respective identities (that is, number composition), although some mixing of covey members was noted, and that coveys seemed to have a lead bird directing covey behavior.

Robinson (1957:52) in Kansas, observed a mutual avoidance among coveys in the midday hours as evidenced by the spacing of covey headquarters. Brief vocalization by covey *members "at awakening, when* scattered, or before roosting . . . keeps a covey apprised of the location of neighboring coveys," and such vocalization "may be epideictic in . . . function, spacing out coveys and regulating density" (Stokes 1967: 19). These actions imply, therefore, space-regulating mechanisms, based on social behavior, in quail populations.

Prehunt densities of quail on this area were comparatively high (0.3 to 0.6 bird *per acre in the fall*) compared with other populations in southern Illinois (Hanson and Miller 1961:73, Table 2). Leopold *(1933:58) stated: "In birds, until more* is known about the subject, the game manager would probably be wise to assume that he cannot build up bobwhite quail or Hungarian partridge on large areas beyond a bird per acre (measured in the fall), and even this can be attained only on the most favorable range." We believe that, with proper management, fall quail densities can exceed one bird per acre by several times. Under ideal habitat conditions, the only logical limit to a quail population is that of spatial tolerance associated with social behavior. When such limits are approached, spacing of coveys tending toward uniformity will be expressed.

Thus, the game manager should be concerned with maximum dispersion as well as maximum abundance of quail. He should not become so involved with the implementation of a particular management program that he fails to note both the number and the dispersion of birds he is managing. *The measure of dispersion should indicate* to the manager the effectiveness of his program. The management program on the Dale Area does not appear to be effective for quail, because, in 4 years, quail abundance did not increase and no trend toward uniformity was apparent in the pattern of dispersion for the prehunt periods.

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